WELCOME TO PERIOD 20

CAUTION: Large magnets on the tables can damage your electronics. Keep your phones, tablets, calculators, watches, etc. off of the table.

Homework Exercise #19 is due today.
What are electromagnets and solenoids?
How can current be induced?
How can a superconductor be used to float a magnet?

Put away your phones and electronics. The large magnets will damage them.
Permanent magnets from magnetic domains

Material with randomly aligned magnetic domains is NOT magnetized.

Magnetized material has magnetic domains aligned in the same direction.

- Charges moving within some types of materials produce magnetic forces.

- Magnetic energy results from the forces between magnets.
Electromagnets from an electric current

- When current flows through a wire, a magnetic field is created around the wire.
- This magnetic field can attract or repel another magnetic field.
Magnetic fields

- Magnets set up a condition in their surrounding space known as a magnetic field.

- When objects sensitive to magnetic forces are placed in a magnetic field, the objects experience a magnetic force.

Magnetic field surrounding a bar magnet
Electromagnets and solenoids

**Electromagnets** use the magnetic field around a current carrying wire to attract or repel the magnetic field from another electromagnet or a permanent magnet.

**Solenoids** are electromagnets whose current-carrying wire is wrapped into a coil.
Magnetic field of a solenoid

How can you increase the strength of the magnetic field surrounding a solenoid?

1) Place a metal rod or core inside the coil of wire
2) Increase the current flowing through the wire
3) Increase the number of turns of wire in the coil
Circuit breakers

A circuit breaker opens the circuit if a dangerously large current is present. It prevents fires due to joule heating.

If the current becomes too large, the magnetic field around the solenoid becomes strong enough to attract and separate the steel contacts and open the circuit.
How is current generated (induced)?

• Charge moving through a conductor produces a surrounding magnetic field.

• The opposite is also true. A moving magnet induces moving charge (current) in a wire.
How are magnetic fields induced?

A moving magnet creates a changing magnetic field. This changing magnetic field **induces a changing current in a nearby conductor**.

The induced current in the conductor **induces a second magnetic field** around the conductor.

The two magnetic fields **interact and repel**.

- **A changing magnetic field induces a current in a wire.**
- **The induced current in the wire induces a magnetic field around the wire.**
- **The induced magnetic field around the wire interacts with the original magnetic field, producing a repulsive force on the wire.**
A solenoid induces current and magnetism

Why does the ring float?

1) Alternating current through the solenoid coil induces a changing magnetic field.

2) This changing magnetic field induces a changing current in the ring.

3) The changing current in the ring induces a magnetic field around the ring.

4) The two magnetic fields repel and the ring rises above the solenoid.
Superconductivity and induced magnetism

- When superconducting material is cooled to a very low temperature, it has zero resistance.
- Material with zero resistance allows current to flow continually through it.
- A small change in a magnetic field can induce a current in a superconductor.

Hold the small magnet above the superconducting disc. What happens when you release the magnet? (Please do not lose the small magnet!)
Why does the magnet float?

When you drop the magnet, it produces a changing magnetic field.

This changing magnetic field **induces a changing current** in the superconductor.

The induced current in the superconductor **induces a second magnetic field** around the superconductor.

The two magnetic fields **interact and repel**.

A changing magnetic field induces a current in the superconductor.

The induced current in the superconductor induces a magnetic field around the disc.

The two magnetic fields interact and repel. The magnet is repelled by the superconducting disc and it floats.
BEFORE THE NEXT CLASS...

✓ Read textbook chapter 21
✓ Complete Homework Exercise 20
✓ Bring a blank Activity Sheet 21 to class.